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ABSTRACT

This annotated bibliography attempts to answer the following questions: (1) What is criticial thinking? (2) Can it be taught and to whom? (3) Which methods are most practical for teaching critical thinking to secondary students? and (4) Can its acquisition be tested? The first question researches the literature for a definition of the term. The second examines the age group which benefits most from instruction. The third question presents practical methods for teaching the skill, and finally, the fourth investigates the possibility of testing acquisition of critical thinking skills. The literature in this paper represents, with minor exceptions, thought on the subject within the last thirty years. Valuable explanations on thinking and cognitive psychology were contained in the material reviewed for this study, but information abstracted pertains only to the categories in question. The subject for this paper was limited to critical thinking in the secondary school, but research and methods outside that arena were included if they added depth to the study. (JD)

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THE QUESTION OF CRITICAL THINKING:
AN ANNOTATED BIBLIOGRAPHY

by

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INTRODUCTION

A renewed interest in teaching critical thinking is attracting the educational community. Futurists believe that our nation's entrance into a high tech, information society will be marked by constant change. As workers, citizens, parents and consumers, adults must use critical thinking in everyday life. Educators emphasize that the need to make crucial decisions in our democratic society demands critical-thinking ability.

Boyer (1984) identified "thinking critically and communicating effectively as essential goals of the school," but Halpern (1984) noted that schools have failed to teach students the mechanics of thinking. Beyer (1984) said that although there is agreement among educators in establishing thinking as the goal of education, the type of thinking skill in which the students should be trained is not clear. As a result, programs are muddled and offer no uniform methodology.

Many researchers are examining various types of thinking skills, including critical thinking. They see that the need to teach critical thinking goes beyond the goals of education and our democratic society: it is the crux of a satisfying life (The National Commission on Excellence in Education 1983).

STATEMENT OF THE PROBLEM

Educators traditionally include the ability to use thinking skills as an important goal of education. Dewey advocated re-

flective thinking early in this century (Kitchener 1983). Adler (1982) called for exercising critical judgment as a skill of learning. Our democratic society predisposes the schools to truly educate young people for decision-making. The consensus of educational literature calls for the necessity of teaching the higher cognitive skills to ensure quality education. In reality, though, classroom hours are too often spent in rote memorization of subject matter. Goodlad (1983) reported on schools where knowledge was only to be acquired, not assimilated; students were not required to use the tools of clear thinking. Sizer (1984) concurred, stating that teachers recognize the need to teach critical thinking skills, but normally require only low-level learning (Tanner, "Review of Horace's Compromise"). The National Commission on Education (1983) was critical of the method of education which failed to foster a reflective individual.

PURPOSE OF THE STUDY

Although the acquisition of critical thinking is a fundamental goal of education, the diverse approaches and numerous terms given to the skill make the practical application perplexing (Skinner 1971). Many teaching methods in secondary schools date back to the behavioral psychology of learning prevalent before 1970 (Hannum 1983). Recent research, however, offers a guide for developing a curriculum to train adolescents

in the higher cognitive skills (Lawson 1983 in Learning and Motivation in the Classroom). A review of the literature on critical thinking can help make teaching that skill successful and rewarding.

ORGANIZATION OF THE STUDY

This paper attempts to answer the following questions: 1) What is critical thinking? 2) Can it be taught and to whom? 3) Which methods are most practical for secondary students? 4) Can its acquisition be tested? The first question researches the literature for a definition of the term. The second examines the age group which benefits most from instruction. The third question presents practical methods for teaching the skill, and finally, the fourth investigates the possibility for testing acquisition of critical thinking skills. The literature in this paper represents, with minor exceptions, thought on the subject within the last thirty years. Valuable explanations on thinking and cognitive psychology comprised the material reviewed for this study, but information abstracted pertains only to the categories in question.

LIMITATIONS

The subject for this paper was limited to critical thinking in the secondary school, but research and methods outside that arena were included if they added depth to the study. Examination

of the vast amount of information on the topic was limited only by time. Further investigation of the subject, especially in the area of methods for training in critical thinking, would be an interesting enterprise.

GLOSSARY

Bloom's intellectual abilities and skills --

"comprehension: . . . the lowest level of understanding . . . . application: Use of abstractions in particular and concrete situations.

analysis: . . . breakdown of a communication into its . . . parts such that the relative hierarchy of ideas is made clear.

synthesis: . . . putting together of elements and parts to form a whole.

evaluation: Judgment about the value of material and methods for given purposes." (A Committee of College and University Examiners 1956: 205-207)

crystallized intelligence factor -- ". . . estimate of the developed intelligence at the time of measurement." (Epstein 1978:358)

deduction -- "that process of logical thought moving from general principles to particular cases . . ." (Good 1973:168)

Eight Year Study -- ". . . experimental study of Secondary Education (1933-1941) . . . for experimentation in terms of new understanding of learning and youth needs." (Good 1973:208)

Epstein's Brain Stage Theory -- ". . . 'five periods in which there is a great increase in brain size'. . . . The five periods are: ages three months to ten months, two to four years, six to eight years, ten to twelve years, and fourteen to sixteen years." (Cramer 1981:17)

factorial validity -- (validity, factorial) "determine(s) to what extent a given test best measures certain content areas . . . (Good 1973:636)

fluid intelligence factor -- "an estimate of the child's ability to develop new intellectual competencies - creative intelligence at the age of measurement . . . " (Epstein 1978:359)

formal thought -- "the fourth stage in Piaget's theory of intellectual development. It emerges between eleven and fifteen years of age when people develop ability to formulate hypotheses, reason logically and deal with abstractions." (Halpern 1984:362)

Guilford's Structure of Intellect (structure of human abilities) -- "organization of intelligence or intellectual skills including reference to relationships between different aspects of intellectual ability. . . . eg., Guilford's model of intelligence, etc." (Page and Thomas:326)

induction -- "classically, a method of reasoning by going from the particular to the general . . . " (Good 1973:298)

pathological doubter -- "a person who is not just cautious, but who will never accept anything as proven . . ." (Ennis 1958:157)

phrenoblysis -- "(derived from the Greek meaning the welling up or spurting of mind and/or skull) . . . correlated brain and mind growth spurts." (Epstein 1978:356)

Piaget's Theory of Developmental Stages -- ". . . sensiomotor (birth to approximately 18 months), preoperational (18 months to 7-8 years), concrete operations (7-8 years to 11-12 years,, and formal operations (11-12 years and upward)." (Skinner 1975:295)

protocols -- "oral verbalizations of the problem solving process . . ." (Nugent and Nugent 1983:1)

Raven's Progressive Matrices -- "non-verbal intelligence test . . ." (Page and Thomas 1977:284)

secondary education -- "a period of education planned especially for young people of ages approximately twelve to seventeen . . ." (Good 1973:522)

syllogism -- "two or more premises that are used to derive valid conclusions." (Halpern 1984:370)

symbolic logic -- ". . . study of the logic of statements . . . according to their form and not their content; the statements represented by symbols such as p., q., etc., and logical connections, and, or, if . . . then, . . ." (Good 1973: 344-345)

ANNOTATIONS

WHAT IS CRITICAL THINKING?

Ennis, Robert H., "A Concept of Critical Thinking," Harvard Educational Review. Winter 1962, 32(1):81-110.

The author's thorough examination of critical thinking concluded that adequate definitions do not exist for the concept. He stated that most psychologists and educators have failed to study critical thinking in depth, and that problem solving has been the focus in the study of thought. He said that even Dewey (1933) gave a psychological instead of logical criterion for solving a problem. Ennis concluded that philosophy with its books on logic gives the best answer for the definition of critical thinking. He outlined his idea of thought based on literature which defines critical thinking as "the correct assessing of statements" (Smith 1953). The twelve "aspects" which developed from his examination of the literature were divided into three categories: logical, critical and pragmatic. The author dismissed the concept of value judgments from his model of critical thinking.

A Project Search Development, "Introduction," Critical Thinking and Reasoning: A Handbook for Teachers, Educational Resources Information Center, ED 132 603, State University of New York, Albany, Office of the Regents, 1976A.

The "Introduction" to the Handbook attempted to explain critical thinking from a humanistic viewpoint in that it related value judgments with critical thinking. The authors stated, "the major goal in teaching critical thinking and reasoning is not to make students more logical" (p. 10), as someone who goes "straight to the heart of the matter" (p. 10), but to enable them to better their use of logical skills in making critical judgments. The authors stressed that skill in critical thinking should be taught through discussions where students must learn to support grounds for a belief and then assess and evaluate them. The article noted that this type of thinking dismisses anything not pertinent to the question at hand.

Brabeck, Mary Margaret Knutson, "The Relationship Between Critical Thinking Skills and Development of Reflective Judgment Among Adolescent and Adult Women," in Dissertations Abstracts International, May, 1981, 41:4647-A.

This paper studied two ways in which critical thinking can be considered: 1) a group of skills which develop logical reasoning and/or problem solving, 2) cognitive development which is shown in the stage development theories of Piaget (1970), Kohlberg (1969), Perry (1970) and King and Kitchener (1979). The relationship between the two considerations was examined also. The Watson-Glaser Critical Thinking Appraisal (WGCTA) and the Reflective Judgment Interview (RJI) were used to measure the skill and development of 392 students from high school, college and post graduate levels. The results indicated that although reflective judgment, based on King and Kitchener's 7-stage theory, increased with education, critical thinking remained the same. High critical thinking students did better on the RJI than the low critical thinking subjects. The results of the study demonstrated that critical thinking and reflective judgment are in fact separate, and that critical thinking skills are necessary for the partial development of reflective judgment.

Johnson, Tony W., "Philosophy for Children: An Antidote to Declining Literacy," Educational Forum, Winter 1984A, 48(2): 435-441.

In an attempt to stem the decline of literacy, Johnson outlined Matthew Lipman's program for the Advancement of Philosophy for children. He explained Lipman's successful presentation of a novel, Harry Stottlemeier's Discovery, which helps elementary students develop an appreciation of clear thinking and formulate "good reasons" for actions. He stated that the book focuses on "formal and informal rules of thought" (p. 239), and offers students "examples of inductive, analogical and explanatory inferences" (p. 239). Johnson commented that teachers must be skilled in using critical thinking themselves if Lipman's program is to succeed.

Black, Max, "Introduction and the Aims of Logic," in Critical Thinking, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1952.

In his Introduction, Black explained that the term thinking is used to denote mental activity of any kind: recalling, "making up one's mind, daydreaming" (p. 4). However, he stated, reasoning is a special type of thinking involved with the terms, "'to prove, evidence, follow'" (p. 4); it is a search for a relationship between truths. The author said that to practice the skill of reasoning, which is a natural aptitude, an individual studies logic from a theoretical and practical standpoint. He noted that logic is considered critical when it is based on knowledge and the standards of a particular subject matter.

Smith, B. Othanel, "The Improvement of Critical Thinking," Progressive Education, March, 1953, 30(5):129-134.

Smith stated that critical thinking, concerned with "logic and language," (p. 130) is the examination of a statement of belief to learn what that belief means and to decide whether to accept or reject it. The author listed behaviors which enable people to think critically: 1) to understand the meaning of key words, defining them in one of three ways, ostensively, verbally and operationally, and 2) to distinguish between observation and inference, noting the logical steps between the two. The author, a Professor of Education at the University of Illinois, suggested that classroom discussions of current affairs is one area which requires critical thinking. Questioning leads students to apply critical thought to conclusions drawn from observations. Smith discussed the question of transfer of the skill of critical thinking and concluded that if it becomes a habit it can be applied in other areas.

Kitchener, Karen Strohm, "Educational Goals and Reflective Thinking," The Educational Forum, Fall 1983, 48:75-95.

All levels of education call for the development of critical thinking, inquiry, problem solving and/or reflective thinking but, Kitchener argued, confusion exists on the nature of these educational goals. The author discussed Dewey's role as the father of reflective thinking and mentioned his responsibility for the many terms used interchangeable with that process including critical thinking. The author compared the process of reflective thinking, which begins with the cognizance of a problem, winds through the creation of ideas for a solution to the development of hypotheses, and ends in a judgment, with the critical thinking research tradition. Critical thinking was considered two ways: 1) as traditional logic and 2) as a process of general problem solving. The author argued that the second is more compatible with Dewey's reflective thinking scheme but neither is appropriate. The author discussed these philosophical differences. The article reported that reflective judgment scores for bright high school juniors, college juniors and doctoral level graduate students were unusually low although the scores increased with the age and education of the individual. It concluded that reflective thinking is often taught as critical thinking skills.

Dewey, John, "What Is Thought," in How We Think, Boston: D.C. Heath & Co. Publishers, 1910.

Dewey listed various types of thinking, but explained reflective thought as a process that ends in a belief which has been carefully examined, supported by evidence and constructed with each idea following the one prior to it. He stated that it is this type of thought that has value in education as opposed to random type or imaginative, although the latter prepares one for reflective thinking. Dewey noted the two subprocesses of reflective thought: a) a recognition of a problem, and b) a search or inquiry to determine the answer. He called this thinking a "fork-road" (p. 11) situation where the choice of road is made under the scrutiny of facts and evidence.

A Committee of College and University Examiners, "Educational Objectives and Curriculum Development," in Taxonomy of Educational Objectives, Benjamin S. Bloom, Editor, New York: David McKay Company, Inc., 1956.

Bloom's Taxonomy referred to "' intellectual abilities and skills'" (p. 38) as critical thinking, reflective thinking or problem solving. The authors said that an individual has intellectual abilities and skills when he can find "appropriate information and techniques in his previous experience to bring to bear on new problems and situations" (p. 38). The skills are distinguished from the abilities in that the former is a method of operation and technique, and the latter is knowledge the student brings to the situation plus the skills, explained the authors.

Landis, Richard E., and William B. Michael, "The Factorial Validity of Critical Thinking with the Context of Guilford's Structure-of-Intellect Model for a Sample of Ninth Grade Students," Educational and Psychological Measurement, 1981, 41:1147-1166.

The rationale for this study was to compare three critical thinking tests with Guilford's (1967) SOI model in an attempt to clarify the meaning of critical thinking. The authors hypothesized that the SOI tests contained the abilities basic to critical thinking. Four hundred ninth grade students were tested on the SOI and one of three critical thinking tests: Watson-Glaser, Curry and Cornell. Correlations between the SOI and the tests indicated that abilities associated with critical thinking are cognition and/or evaluation of words, groups of common words, relations between words and ideas, written or verbal instructions, and a change of words and ideas. The tests did not offer any substantial correlation with Creative Production.

Burke, Paul J., "Testing for Critical Thinking in Physics," American Journal of Physics, December, 1949, 17(9):527-532.

Burke clearly differentiated between two types of teaching in science, and explained their relationship to critical thinking. The first type examined dealt with the strict scientific method by which the professional scientist works. The second described a behavior important to everyone: "'. . . a working sense of the real nature of knowledge, of sound knowledge as distinct from mere guesswork opinion, dogmatic belief . . .'" (p. 527). It is what Downing called the "'the safeguard(s) of scientific thinking' and is very often called critical thinking" (p. 528). Burke believed that since critical thinking is abstract, it can be tested only when it takes on concrete meaning with subject matter application. He tentatively defined critical thinking by listing fifteen general behaviors which can be changed according to their subject matter uses. Formation of hypotheses and creation of experiments were not included in the list because Burke felt that these procedures were part of creative thinking.

Skinner, Ballou, "The Myth of Teaching for Critical Thinking," The Clearing House, February, 1971, 45:372-376.

Skinner listed the various terms given to the process of thinking: "scientific method, scientific thinking, reflective thinking and critical thinking" (p. 372). He noted that educational psychologists have given critical thinking different interpretations. Dewey (1933) explained reflective thinking as a "state of doubt . . ." in which thinking begins as "an act of . . . inquiry" to solve the doubt (p. 372). Watson and Glaser (1964) "considered critical thinking as being composed of five subabilities: inferences, recognition of assumptions, deductions, interpretations and evaluation of arguments" (p. 373). Dressel (1960) listed five steps for critical thinking: recognizing, defining and clarifying a problem, developing possible solutions, selecting a solution and testing it. Additional interpretations from other sources were noted by the author. From these concepts, Skinner concluded that the steps for critical thinking were: "(1) Recognizing a problem, (2) Formulating a hypothesis, (3) Gathering pertinent facts or data, (4) Testing the hypothesis, and (5) Drawing conclusions" (p. 373).

Beyer, Barry K., "Improving Thinking Skills--Practical Approaches," Phi Delta Kappan, April, 1984, 65(8):556-560.

Confusion about thinking skills led Beyer to identify critical thinking as a combination of the broadly based processes of problem solving, decision making and conceptualization, and the "'micro-thinking'" operations of Benjamin Bloom: "recall, comprehension, application, analysis, synthesis and evaluation" (p. 558). He explained that Bloom's taxonomy is used to serve the broadly based processes. Those processes, noted the author, are distinct from each other and have their own set of steps. Skills he listed for critical thinking were based on Robert Ennis' work and included: distinguishing between facts and claims, and between relevant and irrelevant information, determining the reliability and accuracy of information and "strength of an argument" (p. 557), identifying types of assumptions and ambiguous claims, and recognizing "logical inconsistencies" (p. 557) and bias.

CAN CRITICAL THINKING BE TAUGHT AND TO WHOM?

Research from Piaget's Developmental Theory

Piaget, J., "Intellectual Evolution from Adolescence to Adulthood," Human Development, 1972, 15(1):1-12.

Piaget theorized that individuals aged fourteen-fifteen and beyond can begin "to reason in terms of verbally stated hypotheses" (p. 3), a formal reasoning process. He noted that students eleven-fifteen years old from the better schools of Geneva showed formal operational reasoning in experiments conducted, but research on students from other types of schools and social environments indicated that some subjects remained at the concrete level. Piaget believed that all individuals can develop formal reasoning if the environments and experiences give enough "nourishment" for this growth. He hypothesized aptitude may keep some individuals, even those in proper environments, from reaching formal levels in particular disciplines, but stated that more investigation is needed in this area.

Siegler, Robert S., and Robert M. Liebert, "Acquisition of Formal Scientific Reasoning by 10- and 13-Year Olds: Designing a Factorial Experiment," Developmental Psychology, 1975, 11(3):401-402.

This investigation attempted to expand research on developing formal scientific reasoning in pre-adolescents. Previous studies of this nature provided experimental procedures which necessitated only prediction and explanation of results from the subjects. (Brainerd & Allen, 1971; Siegler, Liebert & Liebert, 1973). The present study required the subjects to design the experiment. Sixty children from a lower middle class area participated. One half were ten-year-old fifth graders and one half, thirteen-year-old eighth graders. Randomly divided sections were each assigned a specific instructional treatment: "conceptual framework plus analog problems, conceptual framework alone, or control" (p. 401). Although it was suggested that record keeping would aid in solving the problem, only thirty-five kept records. Twenty-three of these children produced all sixteen combinations for solving the problem. Only ten percent of the ten-year-olds who received conceptual framework alone kept records while ninety percent of the older children with the same treatment provided records. The author explained that the ten-year-olds may have not perceived the need for such action. Only after the investigation did the younger subjects understand this necessity, something the older children foresaw without any proof.

Lawson, Anton E., and John W. Renner, "A Quantitative Analysis of Piagetian Tasks and Its Implications for Curriculum," Science Education, 1974, 58(4):545-559.

These writers tested three groups of students, one of which was seventh through twelfth grade students. Six Piagetian tasks were administered by interviewers with 588 interviews conducted. Results showed an average of 26 percent of the students capable of formal operational reasoning. The highest percentage, thirty-four, was found in the twelfth grade; the lowest, seventeen, located in the seventh grade. These results, along with the testing of college freshmen and high school science students, demonstrated that fewer subjects used formal reasoning powers than those tested in Geneva by Piaget. The authors did not offer any particular reason for this discrepancy, except that perhaps these students had never been given the opportunity to develop formal reasoning. The authors maintained that individuals must be exposed to situations and activities in accord with their capabilities but be challenged to "promote progress to higher levels" (p. 558).

Karplus, Robert, Elizabeth Karplus, Marina Formisano, and Albert-Christian Paulsen, "Proportional Reasoning and Control of Variables in Seven Countries," in Cognitive Process Instruction. Research on Teaching Thinking Skills, Jack Lochhead and John Clement, Eds. Educational Resources Information Center, ED 234 997, Franklin Institute, Philadelphia, Pennsylvania, 1979.

The rationale for this study was to shed light on the range of logical reasoning abilities in adolescents from seven countries. Subjects were thirteen-fifteen-year-old students. Approximately 3600 boys and girls, divided equally, participated. The Piagetian tasks, proportional reasoning and control of variables, were used for the testing. Only seven percent of the entire population tested scored in the category representing the consistent use of formal thought. The authors reasoned that formal thought develops gradually, and is often incomplete. They advised teachers to recognize the differences in students' abilities to use formal thought and to strive towards developing this higher form of reasoning.

Danner, Fred W., and Mary Carol Day. "Eliciting Formal Operations," Child Development, 48(1977):1600-1606.

Research by Piaget showed that formal thinking begins around eleven years of age. Repetition of this research, however, indicated that due to the open-ended nature of the Piagetian tasks, many adolescents and adults do not manifest formal operations. The authors of this article asked ten males and ten females from each of grades 5, 8 and 12 to perform three tasks of separating and systematically testing variables. Each subject was tested individually and instructions were open-ended. The authors scored the testing on whether or not one variable at a time was tested. After the subjects' attempts to solve the first two tasks, prompts were given, followed by a third task without prompts. Results were consistent with the authors' hypothesis: the ambiguous nature of Piagetian tasks prevent the manifestation of formal reasoning in subjects tested. With the use of prompts those with formal reasoning ability can solve the problems and carry the ability over to other tasks of that nature, the authors concluded. Age had a definite bearing on the use of formal reasoning. Only one-fourth of the ten year old subjects progressed to formal operational from task one to task three. The thirteen year olds exhibited a higher proportion (8/11), and all but one of the seventeen year olds made the transition. The ratio of prompts per age group was inversely related to the age of the subjects.

Lawson, Anton E., and Warren T. Wollman, "Encouraging the Transition from Concrete to Formal Cognitive Functioning: An Experiment," Journal of Research in Science Teaching, 1976, 13(5):413-430.

This experiment dealt with fifth and seventh grade students. The essential problem was whether or not instruction can be designed to change students in these groups from concrete operational to formal operational in controlling variables and to enable them to transfer their ability to perform at a formal level on other tasks. Piaget and Inhelder (1958) claimed that any attempt for change was futile until adolescence. The authors also asked if there was a relationship between the students cognitive level and their aptitude to gain from instruction. The procedure for the experiment involved pretests for both experimental and control groups to rank students at their appropriate cognitive levels. The experimental groups underwent four training periods for controlling variables. Posttests for each group followed. Results of the testing showed a significant gain in cognitive skill and specific transfer for the experimental group. The fifth graders reached a level between early formal and full formal operational. The seventh graders tested at nearly full formal operational. Success on non-specific transfer was not as apparent. The more formal operational pretested student seemed to benefit the most from training.

Ausubel, David P., "The Transition from Concrete to Abstract Cognitive Functioning: Theoretical Issues and Implications for Education," Journal of Research in Science Teaching, 1964, 2:261-266.

In this article, the author explained that Piaget's age levels for cognitive development are approximations. He emphasized that a twelve year old, for example, may use formal operations for a time, and then turn back to the concrete level when given a difficult problem to solve. Because of various levels of difficulties within subject matter areas, Ausubel indicated that reasoning levels develop at various times for an individual depending on his "abilities and experience" (p. 263) in the discipline studied. He maintained that if the developmental levels are valid, then only a certain amount of acceleration from one level to another is possible. ". . . maturational considerations impose a limit on such acceleration" (p. 264). However, he stated that adults and adolescents can proceed from one stage to another rather rapidly because of their developmental habit of functioning formally. He emphasized the importance of determining readiness when training for intellectual improvement.

Lawson, Anton E., and Jonathan M. Bealer, "The Acquisition of Basic Quantitative Reasoning Skills During Adolescence: Learning or Development?" Journal of Research in Science Teaching, 1984, 21(4):417-423.

The reasoning skills of proportion, probability and correlation are considered critical to scientific literacy. The use of these skills is common to everyday life. The authors of this study hypothesized that these reasoning skills were due to classroom instruction. Three hundred and ninety-one students in grades 6, 8, 10 and 12 were given a paper and pencil test of five items. One item tested proportion, two probability and two correlation. It was found that students improved somewhat in these skills as they grew older. The analysis of the results, however, showed that improvement did not occur because of classroom instruction, but because of cognitive development. Further analysis indicated that students who reason more ably tend to enroll in the more difficult science courses. The implications for schools, said the authors, is to plan existing courses, or develop new ones which enable students to develop these basic reasoning skills. Real world "situations and applications" should be part of these courses, stressed the authors.

Research from Brain-Stage Theory

Epstein, Herman T., "Growth Spurts during Brain Development: Implications for Educational Policy and Practice," in Education and the Brain, The Seventy-Seventh Yearbook of the National Society for the Study of Education, Part II, Jeanne S. Chall and Allan F. Mirsky, Eds., Chicago: The University of Chicago Press, 1978.

Epstein's research indicated that recent studies in the neurosciences have a direct bearing on curriculum development. He showed how brain growth spurts concur with Piaget's stages of mental growth and called this phenomenon phrenoblysis. In explaining the work of Cattell and his associates (1971), Epstein explained that general intelligence can be divided into "crystallized intelligence factor and fluid intelligence factor" (p.358). The latter value in verbal, numerical and reasoning capacity develops its greatest capacity at age eleven, a brain growth period. At age thirteen and one-half, the value is close to zero. This fact, the author pointed out, may offer support to those who teach in junior high and find little acceptance of new intellectual abilities. Some of these children never regain any interest in learning if subjected to challenges beyond their current capabilities. However, Epstein admitted that some of the "turn-off" at this age could be related to reasons psychological. He recommended exposure to information and direct experience, and to perfecting skills of memorization at this plateau of brain growth, in place of "pressure for elaborate inferences about the nature and interrelationships of experiences" (p. 364).

Toepfer, Conrad F., Jr., "Brain Growth Periodization Data: Some Suggestions for Rethinking Middle Grades Education," High School Journal, March, 1980, 63(6):222-227.

Utilizing research from colleague Herman Epstein, Toepfer disputed educational policies in the middle schools. The author explained that because of brain growth periodization, ten-twelve year olds experience an average growth of forty months in mental age, while twelve-fourteen year olds experience only seven month's growth. The research indicated that students in the former period are capable of developing higher cognitive thinking skills because brain synapes are growing and axons and dendrites are lengthening. When this rapid growth subsides during the next period, twelve-fourteen, further development ceases and students are more likely to learn only within their "existing 'strike zones'" (p. 225). Toepfer advocated teaching strategies which review already learned facts and skills, and prepare for future accelerated growth. He cited research which indicated a high level of "turn-off" due to "over-challenge" (p. 225). Thirty percent of seventh and eighth grade students with I.Q.'s of 120 developed serious academic achievement problems for the first time during this period. Twenty-three percent of these youngsters never surmounted the problems during their high school years. He stressed the importance of analyzing the readiness of students to begin learning formal operations.

Arlin, Patricia Kennedy, "Cognitive Levels Matching. An Instructional Model and a Model of Teacher Change," in A Child's Brain, Mary Frank, Ed., New York: The Haworth Press, 1984.

Arlin explained that interest in neurobiology has led to Cognitive Levels Matching (CLM). She listed Piaget's four stages of development as the cognitive levels, and compared them to brain growth stages. She quoted the hypothesis of the CLM project stating that ". . . at the onset of the stage of formal operations . . . functional changes will only occur in the presence of appropriate instructional intervention . . . "(p. 101). CLM urges teachers to form a developmental outlook in changing instruction to look at tasks from a "child's point-of-view" (p. 108), the author noted.

WHAT ARE THE METHODS FOR TEACHING CRITICAL THINKING?

Training in Logic

Bauman, Robert P., Thomas Wdowiak, and Irene Loomis, "Teaching for Cognitive Developments," in Cognitive Process Instruction, Research on Teaching Thinking Skills, Jack Lochhead and John Clement, Eds., Educational Resources Information Center, ED 234 997, Franklin Institute, Philadelphia, Pennsylvania, 1979.

The purpose of this program was to prepare students for abstract thinking in physics courses by teaching them logical thinking by means of mathematics. The premise for the course was to enable the student to become mentally involved in a step by step passage through mathematical levels of reasoning and eventually to single sentence symbolic logic. Problem solving skills based on Bloom and Broder was another part of the course. Empirical appraisal of the program was difficult to obtain, but "qualitative and anecdotal appraisals" (p. 270) were positive. Tests designed to measure development from concrete to formal operational showed a gain of one step in students exposed to this course. The authors concluded that teaching can change the level of intellectual development, but the following elements must be present: 1) "basic techniques of problem solving" (p. 273), 2) student involvement in the learning process, 3) "hard questions about easy material" (p. 273) and 4) motivation.

Johnson, Tony W., "Successes of the Philosophy for Children Program," in Philosophy for Children: An Approach to Critical Thinking. Bloomington, Ind.: Phi Delta Kappa Educational Foundation, 1984.

Johnson cited research which demonstrates the effectiveness of Matthew Lipman's program. Of particular relevance was a study by the Educational Testing Service of two school communities in New Jersey where the program was taught to students in grades five through eight. Results of the experiment indicated that improvement in formal reasoning occurred in three out of the four grade levels. (The author did not point out which grade failed to show improvement). Johnson mentioned that teachers considered the students "more curious . . ., and better able to reason after implementation of the program" (p. 30). Also cited were pre- and posttesting results in Bethlehem, Pennsylvania schools where sixth graders in 29 out of the 32 classrooms involved improved in formal reasoning skills after the program was put in use.

Cromie, Robert G., "Logic Puzzles and Piaget's Stage of Formal Operations," School Science and Mathematics, November, 1982, 82(7):607-617.

Citing Aron's research which indicated that only one-third of the population reaches formal operations, Kuhn's study on developing formal reasoning with the use of repeated encounters with problem solving, and Lewis' study on the increases in critical thinking for students subjected to syllogisms, converses, contrapositions and induction, the author proposed logic-puzzles for junior high school students. With puzzles, Cromie maintained, the students' interest level is high and they learn logic naturally. He stated four steps in constructing a puzzle: "(1) make up a set of implications comprising a syllogistic argument of three or more steps, (2) reword them using the concepts of necessary conditions, sufficient conditions, the contrapositive . . . , and (3) rearrange the order" (p. 614).

Dreyfus, E., and E. Jungwirth, "Students' Perception of the Logical Structure of Curricular as Compared with Everyday Contexts-Study of Critical Thinking Skills," Science Education, July, 1980, 64(3):309-321.

The question of transfer of critical thinking skills was the thrust of this study. Four multiple choice tests containing logical fallacies in different contexts were administered to 334 Israeli ninth graders. Two of the tests were based on material that the students had experienced or studied. The content of the other two tests was nonsensical. For scoring "the correct choice was predetermined according to the 'standards of formal critical thinking'" (p. 312). The results indicated that students reacted to each test differently, although they had been asked to determine correct choices in the same sound logical manner on each instrument irrespective of its content. It was demonstrated that students perceived the items subjectively instead of objectively. The authors contended that these results gave evidence that students were unable to transfer critical thinking from one content area to another because they did not follow the rules of formal logic.

Use of Questions, Discussions and Writing

Skinner, S. Ballou, "Cognitive Development: A Prerequisite for Critical Thinking," The Clearing House, March, 1975, 49:292-297.

Skinner recommended giving students practice in thinking critically about specific disciplines to affect a change in their thinking abilities. He suggested that students look for assumptions and use deductions, inferences and logic when testing hypotheses. He stated that classroom activities can develop critical thinking if teachers are proficient in their academic area, enthusiastic and capable of providing the conditions for inquiry.

Poel, Robert Herman, "Critical Thinking As Related to PSSC and Non PSSC Physics Programs," in Dissertations Abstracts International, February, 1971, 31:3983a.

In this investigation, Poel examined the role of teacher-pupil verbal interaction in promoting critical thinking. One thousand physics students in 27 high schools were tested. Also, thirty physics classes were observed. Poel concluded that teacher-pupil verbal behaviors which cause the student to become involved in the learning process best develop critical thinking skills, and that time spent on verbal behaviors did not differ significantly between PSSC and non PSSC classes, but did differ between classes which were subjectively determined to be more or less able to acquire critical thinking skills.

Sizer, Theodore, "Coaching," in The Paideia Program, An Educational Syllabus, Essays by the Paideia Group, New York: MacMillan Publishing Company, 1984.

Sizer gave examples of questioning that enable a student to elicit his own thinking and become adept at intellectual skills which include critical judgment. He stated that the teacher or coach must meet the student one-to-one using the student's work as the basis for coaching. Immediate feedback and clever criticism are necessary for proper coaching said the author. The technique varies, but becomes more abstract as the student grows older, Sizer stressed. He concluded that the essential problem is for the teacher to learn how the student uses his mind so as to set that mind to work.

Allen, Rodney, and David E. LaHart, "Critical Thinking Skills and Energy: Using Energy Error Cards in Geography Classes," Journal of Geography, 1981, 80(2):64-70.

This article offered practical ideas for teaching critical thinking without using value judgments. The authors, one an education professor at Florida State and the other a staff member of the Florida Solar Energy Center, developed hypothetical situations which were realistic and taught the student to examine statistics, and read charts and maps correctly to determine if an error in thinking occurred in each situation. The authors suggested that the teacher probe to lead students to ask the correct questions and look for the right evidence.

Nugent, Susan Monroe, and Harold E. Nugent, "Teaching Critical Thinking: Protocols in the Classroom," Educational Resources Information Center, ED 236 675, Paper presented: Annual Meeting of the Conference on College Composition and Communication, Detroit, Mich., 1983.

The theory that protocols are the "windows into the thinking, reading and writing process" (p. 1), caused these authors to develop a critical thinking and problem-solving class for college freshmen who exhibited a lack of reasoning skills. Although the paper emphasized problem solving, an interdisciplinary course, Critical Thinking, taught these same skills. The method for using this approach was presentation of a problem which was solved orally. A careful reading of the problem was the crucial first step. Working with partners, students used different strategies: acting out, drawing or diagramming. Partners also encouraged the process by offering cues. The benefits that developed from using protocols were: careful reading of the problem, forming an awareness of the right problem, slowing down approach to solving problems, and providing "opportunities for identification, practice and evaluation of problem-solving strategies" (p. 6).

Statkiewicz, Walter R., and Robert D. Allen, "Practice Exercises to Develop Critical Thinking Skills," Journal of College Science Teachers, February, 1983, 12:262-266.

This article explained a method used by the authors in a college-level general biology course to further develop the critical thinking skills outside the classroom. It also assessed and evaluated the program's effectiveness. The out-of-class exercises were a multiple-choice format requiring students' justification for each choice. Criteria for proper justification called for the consistent use of biological concepts and information applied in such a way as to forego any other argument. An evaluation of the method revealed that students receiving higher grades continued to improve with practice problems, while those in the "D" range failed to improve as time passed. A positive correlation between grades on practice problems and examinations indicated that a transfer of the skill to new situations was highly probable as a result of this method of teaching.

Moll, Michael B., and Robert D. Allen, "Developing Critical Thinking Skills in Biology," Journal of College Science Teachers, November, 1982, 12:95-98.

Pre-tests to determine recall and critical thinking ability were administered to students enrolled in one section of an Introductory Biology Program. The students were then exposed to a teaching program that involved video presentations and discussions which were initiated by carefully constructed questions. Writing practice problems were also part of the program. Post-tests administered at the end of the semester demonstrated improvement in critical thinking as well as content assimilation. To prove that additional knowledge learned during the semester did not cause the increase in critical thinking skills, other studies were examined. In one, students in an experimental group were given far more information and required readings, yet did not score significantly different than the control group. In the other study, students were given the same pre- and post-tests mentioned above, but their class work emphasized memory recall. The posttest scores concurred with the first study: mere knowledge of a discipline did not develop critical thinking skills.

George, Diana, "Creating Contexts: Using the Research Paper to Teach Critical Thinking," English Journal, Sept., 1984, 73:27-32.

This article offered practical suggestions for helping students to think critically through writing research papers. George gave the following proposals conducive to forming higher levels of cognition while writing a paper: to develop the ability to abstract information from what is read, to use partnership learning which involves teacher and students, to continually critique and brainstorm, to assign a common topic evolved from content developed in class, to demand constant examination of what is read, and to require a term-length assignment to insure familiarity with the information that is read and discussed. The author stated that although students may have not reached the stage to enable them to think critically, they must be "moved through referential relationships to rhetorical relationships." (p. 28).

Elbow, Peter, "Teaching Thinking by Teaching Writing," Change, September, 1983, 15:37-40.

Elbow, the director of Writing Programs at the State University of New York, began this discourse on teaching thinking by advocating creative or first order thinking. This type of thinking, he stated, was necessary to generate ideas for conscious and well-ordered critical thinking. Without it, he said, students would not have enough ideas or hypotheses to examine. He noted that in teaching writing he requires creative thinking for the initial exploratory writing, and critical thinking for examining and revising. In revising papers, both the writer and the readers must point out the "central core of reference" (p. 38), identifying the assertion and the premises on which it rests. Because creative and critical thinking are opposites, the author recommended that students be taught to work on them separately as they write a paper, generating ideas and then assessing them in a revision.

Olson, Carol Booth, "Fostering Critical Thinking Skills Through Writing," Educational Leadership, November, 1984, 42(3): 28-39.

This writing instructor compared the process of writing to problem solving. She contended that most people believe clear thinking enables one to write well. However, she stated, the reverse is also true: writing develops clear thinking. Using Bloom's taxonomy of educational objectives to identify the various skills needed for composing, the author listed each step in writing with one of Bloom's cognitive levels: knowledge-prewriting, comprehension-precomposing, application-writing, sharing-analysis, revising-synthesis, and evaluation-evaluation. The author believed that in writing, the whole cognitive domain, not just the higher level critical thinking skills, is sharpened.

Parrish, Berta, Alan Frager and Loren Thompson. "Television in the Classroom: Critical Viewing/Thinking Skill Development," Educational Resources Information Center, ED 216 337, Paper presented at the International Reading Association Conference, Chicago, Illinois, March 29, 1982.

The authors' statistics on television viewing habits of children and teenagers indicated the necessity for educators to use that medium for teaching critical thinking skills. The sample lesson was the development of the critical viewing skill, identification of stereotypes. Students were cued to carefully watch the characters in Thurber's "The Male Animal," but were not told what would be discussed. After viewing, the group was asked to give its reaction to the athlete and the teacher, and reactions were listed. The word stereotype was elicited or provided. Following the general session, small groups read about and analyzed stereotyping. Critical reading/thinking skills taught by this method were 1) "investigating sources, 2) recognizing writers' purpose, 3) distinguishing fact from opinion, 4) detecting propaganda devices" (p. 9).

Fleming, Dan B., "A Neglected Critical Thinking Skill: Recognizing Bias," Indiana Social Studies Quarterly, Winter 1979-80, 32(3):53-56.

The author explained that critical reading/thinking requires a judgment based on standard criteria, but teaching this concept is difficult because of bias the reader/thinker brings to situations of judgment. Past experiences regarding "race, sex, politics, religion, age and ethnocentrism" (p. 53) were identified as bias by Joseph T. Coleman's study on recognizing viewpoint. Fleming examined a social studies skills development project which attempted to locate students' weakness in understanding point of view. Four thousand one hundred students in grades seven through twelve were pre-tested on skills primarily recognizing viewpoint. Following the test, teachers of the experimental group were given information on student results and encouraged to work in the area of viewpoint recognition. Teachers of the control group were given nothing. Post-testing took place at the end of the academic year and results indicated that diagnosing students' weakness was not enough to bring about an improvement in the skill. The author warned of the problem of subjectivity in determining the correct answer to a high level cognitive question.

Dull, Lloyd, "Introduction," Teaching Critical Thinking in the Secondary School, Educational Resources Information Center, ED 013 687, Ohio Education Association, Columbus, 1964.

The author explained that critical thinking is demonstrated by the steps covered in the act of investigating a problem with an open mind, and arriving at a conclusion. He used the terms critical thinking and problem solving interchangeably. Dull stressed that students must have background knowledge and a good vocabulary, as well as skill in language arts and observation, to become adept at critical thinking. He advised instruction in vigilance, discernment and awareness of propaganda techniques, and emphasized the need for good questions to set the stage for learning. The author recommended evaluation of the critical thinking skills by the Watson-Glaser Critical Thinking Appraisal, observation and interview.

A Project Search Development, "Teaching Strategies," Critical Thinking and Reasoning: A Handbook for Teachers, Educational Resources Information Center, ED 132 603, State University of New York, Albany, Office of the Regents, 1976B.

This portion of the handbook listed and explained special "activities, procedures, assignments, methods, techniques, strategies for the teaching of critical thinking and reasoning" (p. 85) in a humanistic manner. The authors advised using these procedures alone to develop a skill and then incorporating that skill into subject matter curriculum. The project designed many loosely structured teaching methods for the following aspects of critical thinking: deductions, assumptions, use of language and fallacies, implications and consequences and use of evidence. A model Values Discussion offered reasons why a teacher should become involved in teaching values in critical thinking. The Appendix included rules or commitments for critical thinking discussions: "doing certain things in a certain way, establishing and observing certain criteria and adopting certain attitudes toward the endeavor itself" (p. 120).

Role of the Teacher

Thompson, Loren C., and Alan M. Frager, "Teaching Critical Thinking: Guidelines for Teacher-Designed Content Area Lessons," Journal of Reading, Nov., 1984, 28(2):122-127.

Thompson and Frager, both of whom were involved in reading instruction, stated that teachers who wish to train students in critical thinking skills must develop lessons different from the type reading programs most often used in the classroom. The authors offered five guidelines for teaching critical thinking: "1. Stimulate personal interest. 2. Generate active/interactive participation by all students. 3. Use prior student knowledge and experience. 4. Facilitate and encourage skill transfer. 5. Extend comprehension instruction" (p. 123). A model lesson presented involved critical reading and viewing, both of which were demonstrations of critical thinking. Students were given the opportunity to view and read different perspectives of the life of General Custer. Small group discussions played an important part in answering the teacher's questions designed to develop thinking skills. Follow-up activities were assigned to extend the lesson over several class periods and promote skill transfer. The authors reinstated that these lessons cannot be found in teachers' manuals. "They must be the creations of teachers who are competent in their subject fields" (p. 127).

Hunt, E. Joan, and Marcia S. Germain, "The Critical Thinking Ability of Teachers and Its Relationship to Teacher's Classroom Behavior and Perceptions of Teacher Purposes," Educational Resources Information Center, ED 030 625, March 25, 1969.

The rationale for this study was to compare the type of questions and comments used by teachers and teachers' critical thinking ability. From thirty-nine teachers who were tested on the Watson-Glaser Critical Thinking Appraisal the ten highest scoring and ten lowest were chosen to participate in the experiment. These teachers were observed and tape recorded for three one-half hour classroom periods. The thought processes, which were manifested by verbalizations during these observations, were classified by four judges. Results indicated that high scoring teachers provoked almost twice the number of student comments than low scoring teachers, and that questions from the high scoring group showed convergent, evaluative and divergent thinking. The high scoring teachers were more supportive of the students. The researchers stressed the need for critical thinking in teacher education curricula.

Shapiro, Victor, "The Castleman Letter: A Classroom Exercise in Critical Thinking," Social Education, 1981, 45(1):40-44.

The author related an actual experience in teaching critical thinking through the attempt to determine the age of an undated old letter purchased by the author from a New York philatelist. The tenth grade students involved in the investigation developed their own questions and did research in an attempt to come to a solution. The teacher questioned the effectiveness of this somewhat disorganized approach to teaching critical thinking, but concluded that the natural process of learning, in which the teacher only guides the students, is superior.

Martin, David S., "Can Teachers Become Better Thinkers?" Educational Resources Information Center, ED 236 151, Paper presented at Annual Conference of National Staff Develop. Council, 1983.

In response to the emphasis placed on cognitive education for students, the author developed a special intervention program to increase the cognitive domain of teachers. It was his opinion that teachers often lack the ability to develop cognitive skills because of a void in their own education. Nearly half of 1500 teachers in the Chicago area said that "teaching critical thinking to students was a source of difficulty for them" (Radebaugh and Ellis, 1983). Instrumental Enrichment (Feuerstein, 1980) was the guide by which the researcher trained teachers in cognitive education during a seven-month period. Fourteen teachers comprised the experimental group and twenty-three the control group. The Uncritical Inference Test (Haney, 1967), the author's Teacher Self-Rating Scale, and the supervisors' rating form were used to assess the program. The Uncritical Inference Test, apparently non-responsive to the training, offered no significant results. However, the experimental group reported an improvement in "demand high levels of thinking during teaching," "ask challenging questions," and "encourage group discussions" on the Self-Rating Scale (p. 8). Supervisors indicated an improvement in the experimental group on "improvement in methods of fostering cognitive growth in students" (p. 10). One limitation in the program was the fact the teachers in the experimental group were self-selected.

CAN THE ACQUISITION OF CRITICAL THINKING BE TESTED?

Blasi, Augusto, and Emily C. Hoeffel, "Adolescence and Formal Operations," Human Development, 1974, 17(5):344-363.

Blasi and Hoeffel claimed that tests which determine when formal thinking begins are not comparable, however they offered one conclusion: many adolescents and even adults do not function at a formal level. Two ways to look at the data, the article stated, is to suggest that formal thinking can exist in an individual, but not be brought out by the traditional Piagetian tasks, and that specialization is evident in that formal operations can exist in one's area of experience or aptitude. The authors explained that adolescents' personality development does not hinge on the development of formal operations. The fact that they "think consistently at a higher level when faced with problems of a social nature" (Peel, 1971) might be because they have more experience in that area.

Lawson, Anton E., "The Development and Validation of a Classroom Test of Formal Reasoning," Journal of Research in Science Teaching, 1978, 15(1):11-24.

The author developed this classroom test to measure students' cognitive abilities more conveniently than the individually performed Piagetian tasks. The test was designed to include a demonstration by an examiner before the whole group of examinees. The examiner also asked questions dealing with the demonstration and students answered by writing in their test booklets. The test was deemed to have face validity by a group of six judges who were proficient in Piagetian research. A high correlation between the test and a measurement of "subject response on bending rods and balance beam tasks" (p. 17) demonstrated convergent validity. An analysis of the test and four interview tasks showed factorial validity. The test was to be used to classify students in their appropriate cognitive levels. Information from four sources was used to develop a classification table. The basic source was the correlation between the test and responses on interview tasks. The test was judged reliable, although the author mentioned that the classroom test may underestimate the abilities of the class as a whole.

Texley, Juliana T., and John Normal, Jr., "The Development of a Group Test of Formal Operational Logic in the Content Area of Environmental Science," Journal of Research in Science Teaching, 1984, 21(6):589-597.

Texley and Norman developed a test for measuring reasoning skills in adolescents based on Piagetian theory, but more easily administered than the Piagetian Tasks. In the study, 152 secondary students, ranging from age 13½ to 18 3/4, and enrolled in biology or environmental science classes, answered a 60 item test covering the cognitive levels IIA, IIB, IIIA and IIIB of Inhelder and Piaget (1958). One hundred and eighteen junior high students took one or more of the subtests. The Pendulum Task, the Chemical Combinations and Equilibrium in Balance Tasks, a clinical interview, the Differential Aptitude Test (Bennett, Seashore and Wisman, 1961) and information on age and average science grade were used to validate the instrument which also showed to be reliable. In the attempt to develop a valid and reliable instrument, the researches also studied the reasoning level of the students. Results showed a small number of these suburban public high school students were capable of fully formal logical reasoning. "Students in junior high showed a somewhat higher relationship between age and logical reasoning capacity. This might be expected, since theory predicts that these years are crucial to the development of such skills (p. 94). The authors stated that there should be continued investigation on evaluating logical reasoning in other content areas as well.

Pratt, C., and R. G. Hacker, "Is Lawson's Classroom Test of Formal Reasoning Valid?" Educational and Psychological Measurement, 1984, 44(2):441-448.

The validity of Lawson's Classroom Test of Formal Reasoning, which is a convenient paper and pencil test of five of Piaget's formal reasoning tasks, was evaluated by the authors. They concluded that the test did not validly test for formal reasoning. They claimed that Lawson's test was not a match for Piaget's because of test format and administration. With Piaget's clinical interviews, the authors stated, students have the opportunity to test their hypotheses. In Lawson's test only "knowledge of specific application of general principles is examined" (p. 447).

Ennis, Robert H., "An Appraisal of the Watson-Glaser Critical Thinking Appraisal," Journal of Educational Research, December, 1958, 52(4):155-158.

Ennis evaluated the logical validity of the 1952 edition of this popular instrument for testing critical thinking. He listed the five parts of the test, "Inference, Recognition of Assumptions, Deduction and Evaluation of Arguments" (p. 155), and commented on each. He held the belief that some of the items caused a student to be more cautious than the test-makers intended, required an understanding of common knowledge, favored the "pathological doubter" (p. 157), and called on a student's value system to answer some questions. He concluded it was difficult to believe that the thirty-five experts who keyed the test agreed on it unanimously, and stated it would be interesting to know what brought about such agreement.

Berlak, Harold, "New Curricula and Measurement of Thinking," Educational Forum, March, 1966, 30(3):303-311.

A review of twelve paper and pencil tests of critical thinking was offered by Berlak in this article. The tests evaluated were several tests found in A Report of the Eight Year PEA Study (1942), Wrightstone's Test of Critical Thinking in Social Studies (1939), and the Watson-Glaser Critical Thinking Appraisal (1952). Berlak stated that items studied in these tests fail to assess whether the student can use the critical ability tested outside the testing arena. He indicated that the tests do not allow for the measurement of "sequence of thought" (p. 305), but rather evaluate a "single skill" (p. 305). The aspects chosen for testing were less than adequate for the diverse and complex types of thinking that occur in different disciplines, the author argued. He stated that the tests do not assess a student's critical thinking competence in history and sociology where value judgments are often involved.

Modjeski, Richard B., and William B. Michael, "An Evaluation by a Panel of Psychologists of the Reliability and Validity of Two Tests of Critical Thinking," Educational and Psychological Measurement, 1983, 43:1187-1197.

Two popular critical thinking tests and their manuals were evaluated according to standards of the 1974 edition of Standards for Educational and Psychological Tests by a group of fifteen psychologists. The tests were judged on their validity and reliability for research. In respect to validity, there was much variation, however the Watson-Glaser test received a rating superior to the Cornell. Both tests were negatively evaluated in regard to test bias and "lack of cross-validation efforts" (p. 1195). There was variation in the appraisal of reliability and measurement error, but again the Watson-Glaser was rated higher than the Cornell. The authors concluded that the assessment indicated a need for further research and development for the improvement in validity and reliability of these tests for critical thinking.

Walker, N., Jr., "Critical Thinking about Critical Thinking," School Science and Math, March, 1967, 67:271-273.

Walker's main question was whether or not testing subject matter should also test critical thinking. He stated research has shown that critical thinking is inhibited under stress, a condition often present during testing, thus, a poor grade which seemingly indicates a lack of knowledge, may in reality, be an inability to synthesize facts. He asserted that teachers must decide what examinations are to be testing: knowledge of subject matter or critical thinking ability. Because this ability is so often stated as a major objective in education, the author suggested the need for a separate course in learning and testing the skill of critical thinking.

Morgenstern, Carol Feltin, and John W. Renner, "Measuring Thinking with Standardized Science Tests," Journal of Research in Science Teaching, 1984, 21(6):639-648.

An analysis of twelve standardized science tests indicated that ninety percent of the questions asked for recall. The processes of comparing, imagining and analyzing were not necessary. Although the main purpose of education is aiding students' development in thinking, very few methods for testing this ability exist, stated the authors. The Educational Policies Commission (1961) listed the processes of "recalling, imagining, classifying, generalizing, comparing, inferring, deducing, analyzing, evaluating and synthesizing as the rational powers" (p. 639). Specially trained evaluators examined twelve randomly chosen tests for testing the rational powers. From 648 items evaluated, 587 or 90.6 percent tested recall only. The next largest percentage, 2.6 tested evaluation.

Keating, Daniel P., "Precocious Cognitive Development at the Level of Formal Operations," Child Development, 1975, 46: 276-280.

A comparison of psychometrically tested brightness and Piaget's cognitive development measure was the subject of this study. The author raised the question: Are students who score high on psychometric tests precocious as defined by Piaget, or are they only "good test takers" (p. 276)? The subjects were 109 fifth and seventh grade boys whose average ages were 11.3 and 13.1 respectively. They were classified as bright or average in each grade using scores on the arithmetic section of the Iowa Tests of Basic Skills. The 60-item Raven's Standard Progressive Matrices was administered and a select group was evaluated additionally by Piaget's tasks of concrete and formal reasoning. Sixty-two percent of the seventh grade and forty-seven percent of the fifth grade bright students performed at a formal operational level. The author found that the younger bright children scored higher than the average older students.

SUMMARY

Definitions of critical thinking span a wide continuum: logic, reflective judgment, the standards of particular disciplines, and problem solving models.

Ennis (1962) indicated the lack of universal meaning for critical thinking, but named philosophy, with its logic, as the best description. His definition of critical thinking, "a correct assessment," did not embrace the concept of value judgments. Some educators considered critical thinking from a humanistic viewpoint. A Project Search Development (1976A) advocated value judgments as part of critical thinking, but stressed the need for improving skills in logic for making critical judgments. Brabek contended that critical thinking is necessary for the development of reflective judgment. Her model included two components: a group of skills, and cognitive maturation based on the developmental-stage theories of Piaget, and others. Johnson's (1984A) appraisal of Philosophy for Children focused on logic as did Black's assessment of reasoning. The latter pointed out that logic is "critical" when it is based on the knowledge and standards of a specific discipline. Smith declared that "logic and language" are the bases for critical thinking by which a belief along with the factors for accepting or rejecting it are examined. Kitchener called critical thinking both traditional logic and general problem solving. Finally, Dewey's reflective thinking was stated as the recognition of a problem and the search to

determine an answer, and Bloom's taxonomy called critical thinking "intellectual abilities and skills." Landis and Michael's correlation of critical thinking tests and the Structure of Intellect model demonstrated that cognition and evaluation of words, concepts and relationships comprise critical thinking, and that creative thinking is not a component. Burke concurred, eliminating creative thinking from his concept of critical thinking. He also related this concept to a "working sense of the real nature of knowledge, . . . as distinct from mere guesswork, opinion or dogmatic belief," and different from the scientific method of professional scientists.

Skinner and Beyer shared Ennis's concern at the lack of agreement in defining critical thinking. Skinner concluded from his research that the five steps which form the model of critical thinking, follow exactly the scientific method model: recognizing a problem, forming a hypothesis, gathering data, testing the hypothesis and drawing conclusions. Beyer identified critical thinking as a combination of problem solving, decision making, and conceptualization executed through the utilization of the 'micro-thinking' operations of Bloom's Taxonomy of Educational Objectives.

Division of opinion on definition of the term is not the only area of disagreement in the literature or critical thinking. The question of who is capable of formal reasoning and thus of critical thinking has also been the subject of much investigation. Piaget theorized that fourteen and fifteen year olds can begin

formal reasoning processes if given the proper incentive. Stiegler and Liebert's experiment demonstrated that thirteen year olds were capable of some formal scientific reasoning.

Other researchers, however, disagreed. On the one hand, Lawson and Renner, whose work was based on multiple investigations, suggested that only a few adolescents actually use formal reasoning powers. Karplus and his associates found a mere seven percent of their entire testing population capable of consistent formal thought. They reasoned that formal thought develops gradually and is often incomplete. On the other hand, research by Danner and Day indicated that formal reasoning may be more prevalent. They found that the ambiguous nature of Piagetian tasks prevent the manifestation of reasoning ability and that the use of "prompts" can help students solve problems and transfer that ability to other tasks of the same nature. Lawson and Wollman reported that training resulted in a gain of cognitive skill and specific transfer, but students who pretested well at the formal operational level seemed to benefit most from the training. This fact is supported by Ausubel's finding that the variation in abstract cognitive functioning is a result of the "abilities and experience" an individual brings to the study of specific disciplines. Similarly, Lawson and Bealer's study revealed that maturation rather than classroom instruction served a definite role in cognitive development.

Brain growth periodization studies by Epstein and Toepfer indicated that ten to twelve year olds can develop higher cog-

nitive skills, but twelve to fourteen year olds experience nearly zero capacity for cognitive growth. At about age fifteen, brain growth commences rapidly again, and new, higher cognitive skills can be learned. Arlin noted that training for higher cognitive skills must match the acquired cognitive level of the student.

The various methods for teaching critical thinking parallel the diversity of definitions given to this concept. Bauman and his associates reported on a program which prepared students to think abstractly and logically through the study of mathematics. Johnson's (1984B) report on Matthew Lipman's program, which was developed partially on rules of logic, indicated improvement in formal reasoning. Cromie promoted formal operations by the use of logic puzzles. Dreyfus and Jungwirth's investigation advocated the use of formal logic to promote the transfer of the skill from one discipline to another.

Questions and discussions are seen as crucial to developing critical thinking skill. Poel's examination of teacher-pupil verbal interaction concluded that questions which cause the student to become involved in the learning process best develop the critical thinking skills. Sizer offered examples of coaching to enable a student to elicit his own thinking. Although discussions are vehicles to critical thinking, Allen and LaHart indicated that they must be supported by correct probes so students will look for the right evidence. Discussion of a different kind involved protocols. Nugent and Nugent described a program in which students orally solved a problem in the presence of a partner who posed

questions leading to a solution.

Writing is another mode for developing critical thinkers. Statkiewicz and Allen reported on their biology course which required students to give written arguments for the choice of an answer. George offered proposals for writing research papers to develop critical thinking skills in students who may not have reached the state of formal reasoning. Elbow advocated using creative thinking to generate ideas for critical thinking in writing. Finally, Olson used each step in Bloom's Taxonomy to demonstrate parallel stages in writing a paper.

A review of the literature offered still other aspects of critical thinking. Identifying stereotypes was a program used by Parrish and associates. Fleming warned of the bias a student brings to the concept of critical thinking. Dull linked the tools of background knowledge, good vocabulary and observation with becoming adept at critical thinking. A Project Search Development (1976B) advocated teaching the skills of critical thinking as a separate subject, but incorporating the skills into subject matter when students became proficient in using them.

The literature points to the necessity of having teachers who are able to form critically-thinking individuals. Thompson and Frager stated that teachers must be competent in their subject areas. Hunt and Germain's research indicated that the teachers themselves must be highly capable of critical thinking. Shapiro recommended teachers who can act only as guides. Martin's investigation reported the success of an "intervention plan" to

help teachers improve their own skill in thinking.

Research on the evaluation of critical thinking ability also presents a diverse picture. Blasi and Hoeffel claimed that tests to determine when formal thinking begins are not comparable and that Piagetian tasks do not discover areas of specialization in formal reasoning development. Tests created to measure more conveniently the students' cognitive abilities were developed by Lawson as well as by Texley and Normal. The tests were deemed valid and reliable although Lawson stated that his classroom test might underestimate abilities of the class as a whole. Pratt and Hacker, however, concluded that the Lawson test did not meet validity standards because of the inherent inability to allow students to test hypotheses. Ennis (1958) evaluated the logical validity of the Watson-Glaser Critical Thinking Appraisal and found it favored the "pathological doubter" and called on a student's value system to answer some questions. Berlak's assessment of several critical thinking tests said they could not assess the ability to use critical thinking outside the testing arena. Modjeski and Michaels' research found the Watson-Glaser test superior to the Cornell test in their evaluation, but stated the need for improvement in the validity and reliability of these tests. Walker questioned the advisability of testing critical thinking with subject matter and suggested that teachers determine what it is they want to test: critical thinking or subject matter. Morgenstern, Felten and Renner evaluated standardized science tests and indicated that they cannot be used for assessing

higher cognitive skills. Keating's investigation found that students' scores on psychometric tests correlated positively with their cognitive development measured by the Piagetian tasks.

CONCLUSION

What Is Critical Thinking?

Similarities in the diverse meanings of critical thinking are summed up in defining this concept as knowledge and skill working in tandem. The skill to use formal logic is the framework for thinking through questions or problems based on correct content or knowledge. This conception of critical thinking comes closest to Bloom's "intellectual skills and abilities." The definition does not include creative thinking which often generates ideas for critical thinking, and value judgments which come after the critical thinking process has occurred.

Whom Can We Teach?

Students of secondary school age generally should be able to reason formally and thus think critically. Because of diverse backgrounds and development, however, not all students can use these reasoning skills. Some individuals are capable of thinking critically in a specific area but not in another. Periodic brain growth can deter twelve to fourteen year olds from developing new cognitive growth until the brain commences to grow in the next stage. Instruction helps to develop the use of critical thinking skills and aids in transferring the skill to a

novel problem, but that instruction is best utilized by those who already think on a formal level.

What Are the Methods for Teaching Critical Thinking?

Learning the rules of formal logic is a primary means to develop the skill of critical thinking. Questions or coaching which involve the student in the learning process are pedagogically necessary. Discussion and writing are vehicles for utilizing critical thinking skills. Teachers who think critically and are proficient in their academic area are the foundation on which these methods are built.

Can Critical Thinking Be Tested?

Standardized instruments such as the Watson-Glaser Critical Thinking Appraisal can be used to test formal reasoning ability, but the diversity of opinion about critical thinking is demonstrated again in the arena of testing. No one instrument is superior for general assessment of that ability and whether or not it is possible to test knowledge of subject and skill at the same time is open to question.

The present differences in meaning and approach to critical thinking are a challenge to educators. A consistent program to teach students to go beyond rote memorization and unstructured "values" discussions is a basic necessity. Only then will schools produce citizens who can think clearly for decision making in our society.

RECOMMENDATIONS

It is recommended that:

1. Training in the formal rules of logic begin during the rapid brain growth period between ten and twelve years of age, and reinforced during the middle school or junior high age: twelve to fourteen years.
2. The application of these formal rules of logic to particular academic areas begin in the ninth grade and continue through secondary school.
3. Students' reasoning abilities be tested to enable cognitive levels matching for optimum learning.
4. Secondary school teachers be prepared to think critically, as well as become competent in their subject areas, through teacher training and in-service programs.

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